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Ecological evaluation of aquatic invertebrates distribution of Apátkút Creek (Visegrád Mountain, Hungary) in winter

by

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Abstract: Aquatic insects and amphipods were collected between December 1984 and March 1985. The number of species and individuals is high in the creek even in winter. The mean water current is about 1 m/sec. Distribution of larvae primarily depends on the mean velocity of the water. All of the other ecological factors are closely related with the water current. The anthropogenic effects are also discussed.

Key words: aquatic invertebrates, water current, dissolved O_2, stone size.

Introduction

Ecological studies of small creeks in Hungary were carried out mainly from spring to autumn (Dvihally & Ponyi 1956, Entz 1958, Papp 1966, Oláh 1967, 1972, Kiss 1977, 1978, 1979, 1981). Our aim was the investigation of Apátkút Creek during winter. Tourism is much smaller in winter, while we can explore the original and natural situation more precisely.

Some researches (Bengtsson 1981, Macan 1980, Flannagan 1983, Singh *et al.* 1984) pointed out that the invertebrate macrofauna in winter is not necessarily poorer than in summer, although the temperature is lower but the pollution is not so high. Others have opposite opinion (Bagge 1965, Bradt & Wieland 1981, Harper & Harper 1982).

The question is whether the number of species and individuals of invertebrates in Apátkút Creek is rich or poor in winter. The subject of our work was the macro- and micro-distribution of macroinvertebrates in the creek and the evaluation of the ecological factors influencing them, with special regard to water current.

The distribution of running-water organisms is determined first of all by water current (Lepnyeva 1949, Oláh 1967, 1972, Kiss 1978, 1981, Fuller & Mackay 1980, Madsen & Warnocke 1983, etc). Our aim was to measure the mean velocity of the creek water and to relate it to the distribution of aquatic insect larvae.

Considering the complex effect of different ecological factors on the distribution, our task was to examine other ecological circumstances, too. We wanted to know what is the effect of water temperature, dissolved oxygen content, water-depth, and substrate-type on the distribution of invertebrate rhithron organisms.

Description of sampling sites and collecting dates

The creek is situated in the Visegrád Mountain. It runs 9 kilometres towards the north-northeast and then it flows into the River Danube at 1695 riverkilometre, at Visegrád.

Its fall is 250 metres, it has a gradient of 2.73%. It is probably of Old-Pleistocene age. The Visegrád Mountain is mainly from andesite containing SiO_2 in 57.5-62.3%, so the amount of silicon in the creek is bigger than in limestone-streams and the amount of Ca^{++} is naturally smaller.

The bottom is formed of andesite-gravels and breccias, the creek-flow is accompanied by agglomerate, tuff and lavarocks. Silt and sand deposits can be found on the gently sloping and moderate flowing

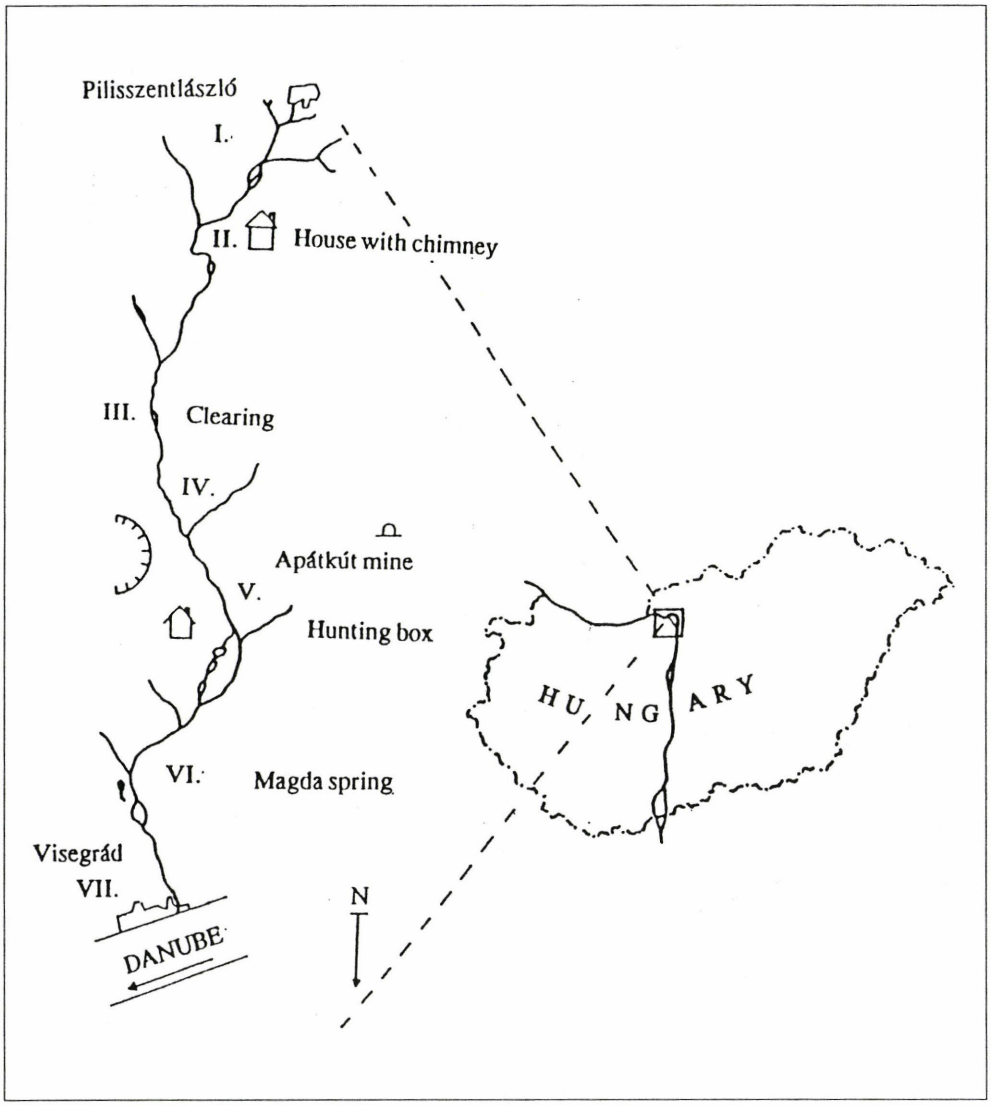

Fig. 1. Map of Apátkút Creek with the sampling sites

transects. Detritus accumulates on these areas, but it can be found among or under rocks on faster flowing area. It collects three or four smaller creeks on the right and left side. These inflows usually dry out during the summer.

The winter in this year was extremly cold and prolongated. So in the beginning of March the temperature was hardly above freezing point, the temperature of the water was 0, 1, 2, 2.5 °C. In the first period pilot samplings were taken, 50 samples two times – on 1st 12, 1984. and 17th 12. 1984. – along the full length of the creek in order to gather many ecological information and to separate 7 areas. These are as follows: I. Pilisszentlászló; II. House with chimney; III. Clearing; IV. Apátkút-mine; V. Hunting-lodge; VI.Magdolna-spring; VII. Visegrád (Fig. 1). Samples were taken 8 times from December 1984 to March 1985.

These transects proportionally divide the whole creek. If we draw a map of ecological circumstances of the areas we explore not only the mosaic-structure of certain areas of the creek but we can also compare them. We can interpret changes of species number and individuals of the macrofauna along the creek on the basis of change of ecological circumstances.

We accomplished invertebrate samples with water-samples to determine dissolved oxygen content and we measured water current. Sampling dates are as follows: 25th 12, 1984. in Visegrád, 22nd 01, 1985 at Magda-spring, 23rd 02, 1985 at Hunting lodge, 28th 02, 1985 at Apátkút-mine, 03rd 03, 1985 at Clearing, 07th 03, 1985. at House with chimney, 07th 03, 1985 in Pilisszentlászló.

Material and methods

Three kinds of methods were used at the same time: we measured the water velocity, the amount of the dissolved oxygen and we collected aquatic insect larvae, too.

The current of water is not steady, actually it has particular pulsation, that is why the measuring instrument registers in a certain range of the scale during the measurement. As a result we registered average values of this range.

We measured areas with different water velocity, and hence we used two kinds of propellers: one marked 3-24245 and the other marked 5-23883. We set up the first one on the faster flowing stretches and the second one on slower flowing stretches. The wings of 3-24245 propeller wind less in direction of rotation, but the wings of 5-23883 propeller form nearly one thread, so even the slower current can move it. Before starting the measurement we checked the calibration of the propellers: we accomplished measurement of water velocity at one point with both propellers and their values were the same.

The determination of dissolved oxygen content took place according to the Winkler-method (Felföldy 1974).

The macrofauna was collected with a special net. The frame of the net was a 20x20 cm, its net was 60 micron mesh-size. Each sample was taken from exactly determined area of the creek (0.1 m^2).

The surface of the water was frozen in 10-20 cm – thick – layer in many places, but it was not frozen to the bottom. As we broke up the ice we did not stir up the bottom, if we did not move the stones. Than we collected the larvae from 0.1 m^2 territory. At the sampling sites we accomplished the following ecological observations and measurements:

average velocity of water: the measurement was done with OTT Current Meter instrument at 25 transects. In case of other places we estimated the water velocity comparing with the result of the previous measurements.

size of stones: we estimated the diameter of the stones, too, it is also an approximal average value, but the data registered in the different sample sites are proportinal to one another.

depth of water

temperature: water and air temperatures were measured with a thermometer with 0.1 °C scale.

other data: detritus, wood branches, leaves, pollution on the sampling place were registered.

The collected material can be found in the scientific collection of the Department of Zoology of Eszterházy Károly Teachers' Training College.

Results and conclusions

First those two ecological factors have to be discussed that have the greatest influence on the distribution of aquatic insect larvae: water velocity and the dissolved oxygen content. The most difficult, and, at the same time, the most interesting parts of conclusions are those relationships between environmental factors and the distribution of aquatic insect larvae.

The water velocity changed between 0.1 m/sec and 3.8 m/sec (Table 1). The water velocity values change in a wide range, the average velocity is rather high (about 1 m/sec). Oláh (1967) and Kiss (1977, 1979) measured much smaller values in the creeks of Mátra and Bükk Mts.

Table 1. Mean velocity of water along the Apátkút Creek

No.	v	No.	v	No.	v	No.	v	No.	v
1	0.O95	6	2.12O	11	2.378	16	2.179	21	3.874
2	0.345	7	1.526	12	1.191	17	0.215	22	1.896
3	2.4O3	8	3.693	13	0.095	18	1.784	23	1.483
4	0.334	9	2.378	14	2.210	19	1.088	24	2.068
5	1.423	10	0.500	15	1.268	20	2.326	25	1.165

No. - number of sampling sites
v - water current (m/sec)

Those sites, where water velocity minimums were observed (Nos 1, 13) – widenings of the creek on flat field – can essentially be considered to be still waters. Sites showing velocity maximums (Nos 8, 21) are micro-waterfalls. The water velocity largely depends on the slope, so the wide interval of its values shows the micro-range of slope of the watercourse.

Two interesting facts can be studied on Fig. 2. The first one is that water velocity changes periodically and it can be explained by the variety of slope, the other one is that beside periodicity, considering the length of the creek, the value of average velocity does not change, and remains about 1 m/sec. Water velocity is determined by water discharge beside the slope. The larger the slope and water discharge are, the bigger is water velocity. Moving downstream along the creek from the source, the water output is increasing because water coming from lateral arms increases the water output. The slope shows decreasing tendency. These two effects compensate each other. This can be the reason that the average velocity is permanent at the whole length of the creek.

The periodicity and wide range of the water current result in wide variety of different aquatic insect community assemblages.

Dissolved oxygen content varied from 4.85 mg/dm^3 to 19.48 mg/dm^3 (Table 2, Fig. 2).

The sampling sites were the same as the points of velocity measurements.

Table 2. Results of dissolved O_2 measurements

No.	O_2	°C	No.	O_2	°C	No.	O_2	°C
1	4.85	1	9	14.53	2	17	8.15	0
2	7.91	1	10	9.68	2.5	18	12.66	0
3	8.60	1	11	14.84	2.5	19	13.10	0
4	5.05	1	12	11.35	2.5	20	17.60	0
5	8.13	1	13	9.52	0	21	19.48	0
6	11.03	1	14	14.23	0	22	9.69	0
7	11.29	1	15	13.83	0	23	14.31	0
8	15.82	1	16	15.95	0	24	15.19	0
						25	9.90	0

No.- number of water samples
O_2- dissolved oxygen content (mg/l)
°C- water temperature (°C)

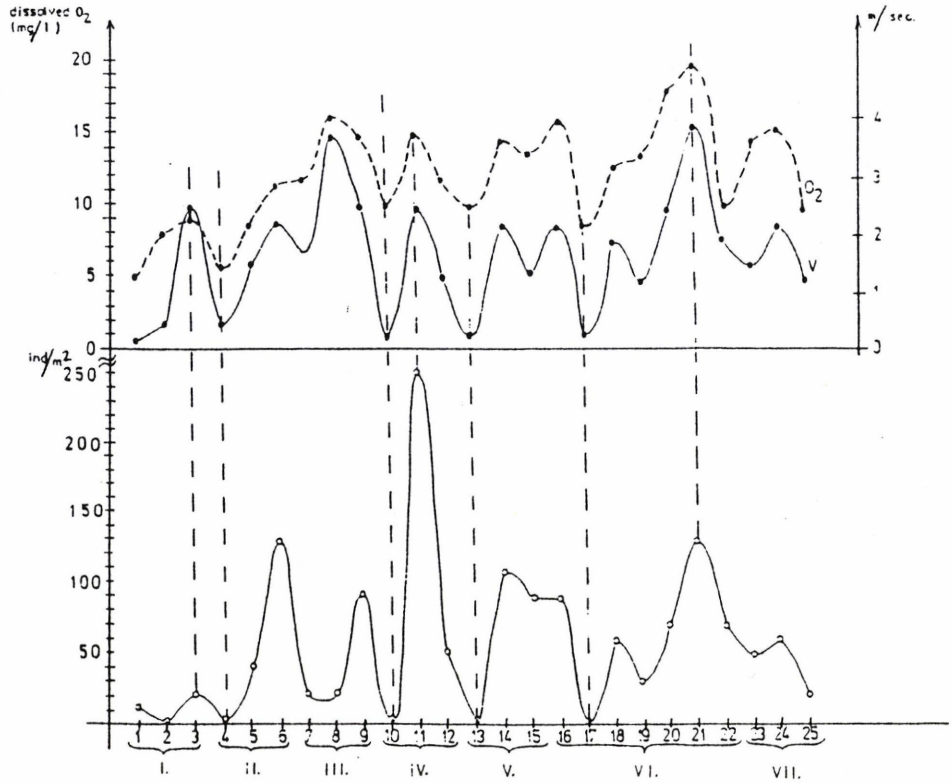

Fig. 2. Water current, dissolved oxygen content and number individuals of invertebrates

It can be seen on the Fig. 2 that the dissolved oxygen curve follows the average velocity curve. High water velocity goes together with large amount of O_2 and (vica versa) low water velocity goes together with low O_2-level.

In many places the water current is fast, but the amount of O_2 does not reach the saturation.

Watersamples 13-25 were taken from water of 0 °C, where the surface of water was frozen. The ice prevents the physical solution of oxygen. The other reason is the pollution. The low oxygen level refers to pollution. At Pilisszentlászló the dissolved oxygen content is really small, although the water velocity is high in some places. Fig. 2 shows well that the water current at Pilisszentlászló goes together with much lower oxygen-level, than with the similar water velocity of further places of the creek. For example at sampling site No. 3 (Pilisszentlászló) water velocity is 2.4 m/sec with 8.6 mg/dm^3 O_2 content, while at the site No. 11 at similar water velocity (2.4 m/sec) the dissolved oxygen content is much higher, almost two times more than the previous one (14.84 mg/dm^3).

The most polluted part of the creek can be found immediately at Piliszentlászló. The origin of the pollution is the sewage water coming from the settlement standing on the sites of the creek and the great amount of litter deposited into the creek.

Fig. 2 shows that the oxygen concentration is increasing after the small values of the beginning, then at the end of the creek it is slightly decreasing again. At Pilisszentlászló the water is strongly polluted, and then from the next place it is clearing up and at Visegrád has

new pollution effect. It is not as serious as at Pilisszentlászló, the removal of rubbish and the sewage-system in Visegrád are obviously more developed.

The degree of pollution in the creek on the basis of the values of dissolved oxygen content correlate with water chemical results of Simonyi (1981).

Altogether 1376 individuals of aquatic insects and amphipods were collected in 174 samples during the sampling program. The collected aquatic insects larvae are as follows:

Ephemeroptera:
Baetis rhodani (277)
Rhithrogena *semicolorata* group (132)
Electrogena lateralis group (96)
Epeorus silvicola (8O)
Ecdyonurus sp. I. (25)
Ecdyonurus sp. II. (6)
Habroleptoides modesta (16)

Plecoptera:
Nemoura sp (71)
Leuctra sp. (23)
Leuctra hippopus (1)
Capnia bifrons (4)
Isoperla grammatica (9)

Trichoptera:
Hydropsyche pellucidula (51)
Rhyacophila fasciata (5)
Rhyacophila obliterata (3)
Lymnephilidae (35)

Coleoptera:
Elmidae (18)

Megaloptera:
Sialis fuliginosa (3)

Diptera:
Empidiae (4)
Simuliidae (18)
Tabanidae (3)

Among the aquatic insects Ephemeroptera, Plecoptera and Trichoptera can be found in largest number of species and individuals. Coleoptera, Megaloptera and Diptera can be found in small number. This is why the distribution of mayflies, stoneflies and caddis-flies will be discussed below.

Juvenile larvae of some species could be identified only to generic level.

Fig. 3 and Table 3 also demonstrate the pollution well. The smallest number of individuals was detected at Pilisszentlászló and number of individuals slightly descreased in the area of Visegrád. Mayflies and stoneflies indicated continuous pollution.

The abundance of mayflies and stoneflies was increasing after Pilisszentlászló. Then at Visegrád, at the new source of pollution, the curves fell almost to the level of Pilisszentlászló. Distribution of Ephemeroptera and Plecoptera were different from the ones of Trichoptera and Amphipoda (Fig. 3).

The two latter curves are running parallel to each other. The reason is probably that habitat and food of the two animal groups are the same.

Fig. 4 illustrates the distribution of 8 species (5 Ephemeroptera, 1 Plecoptera, 2 Trichoptera). Frequency of individuals strongly decreased in the cross-section of Visegrád (except *Baetis rhodani*), but not so specifically as at Pilisszentlászló, so the degree of pollution is smaller at Visegrád.

Baetis rhodani was the most euryecious species. It was distributed uniformly, its number decreased only at Pilisszentlászló. *Electrogena lateralis* was found in large number in the clean upper half of the creek. *Rhitrogenia semicolorata* group, *Epeorus silvicola*, *Ecdyonurus* spp. had small number of individuals in the middle and lower transects but a uniform distribution was found in the clean water section. Number of individuals of Plecoptera and Trichoptera

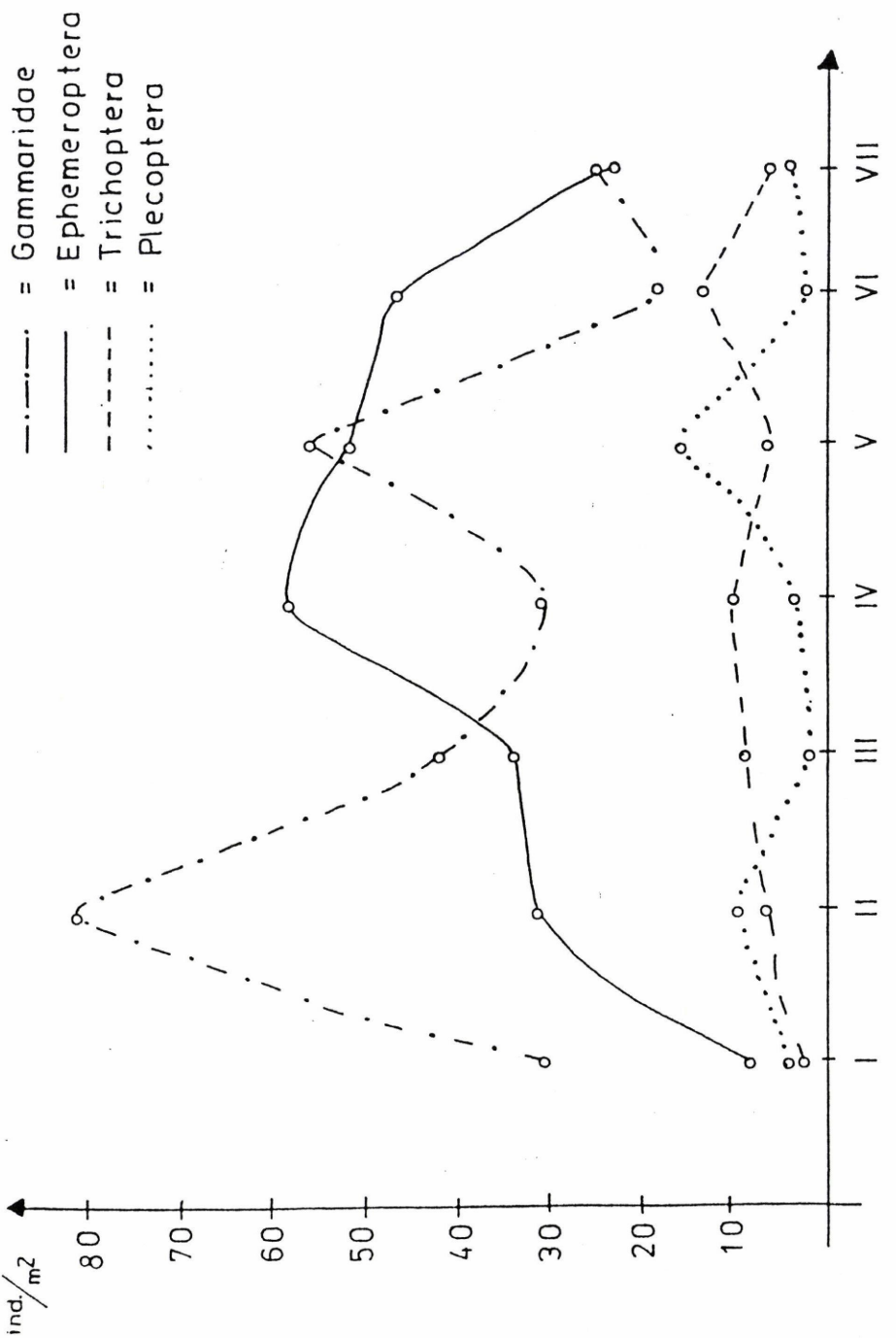

Fig. 3. Distribution of insect larvae and amphipods along the creek

Table 3. Distribution of main groups of aquatic insect larvae and amphipods (ind/m^2)

	Ephemeroptera	Plecoptera	Trichoptera	Gammaridae
Pilisszentlászló	8.4	2.4	2.8	30.6
House with chimney	30.4	5.2	9.8	81.2
Clearing	33.0	6.9	2.3	42.3
Apátkúti-mine	57.9	7.9	2.8	30.3
Hunting lodge	50.4	5.4	14.2	55.6
Magdolna-spring	45.8	12.6	1.6	18.2
Visegrád	22.5	4.2	3.8	22.9

was less than the numbers of Ephemeroptera. The *Nemoura* sp. was distributed on the whole length of the creek, its abundance was the biggest on the middle, clean sites (Fig. 4).

The distribution of the two caddis-fly species was very interesting (two upper species in Fig.4), they almost complete each other: where the *Halesus* sp. was dominant, there was no *Hydropsyche pellucidula* and vica versa, where number of individuals of the second one was high, *Halesus* sp. was not found.

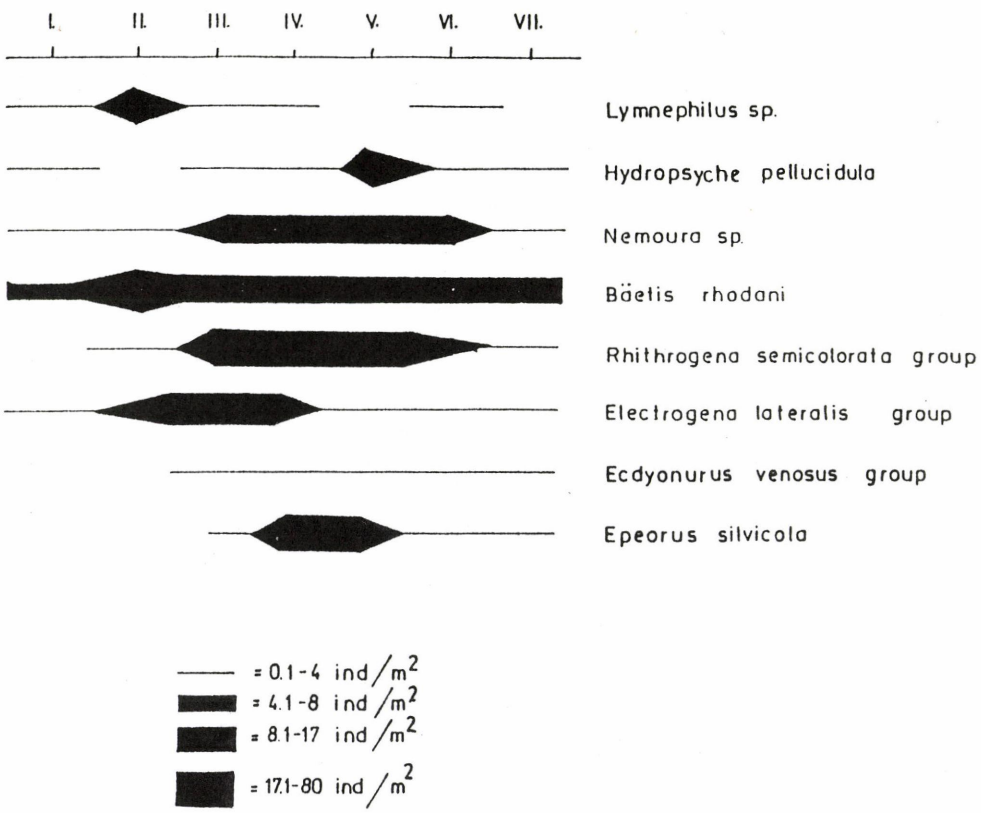

Fig. 4. Distribution of some frequent species along the creek

The reason is not the competition of the two species but their completely different microhabitat use, the different feeding type and way of life.

Hydropsyche pellucidula can be found among stones and catches its prey with net and prefers fast flowing water. *Halesus* can be found in calm reaches among detritus on branches and wood, from which it builds its case.

The distribution of insect larvae is influenced not only by the pollution, water current, food, competition but also by several other factors, e. g. method of egg-laying. The occurrence of *Rhithrogena semicolorata* group along the creek is also the result of that females lay their eggs not in masses but they drop them one by one to the water flying above the water surface.

The water current and dissolved oxygen content have obvious influence on the number of insect larvae. Dissolved oxygen content depends on velocity of water. The number of individuals follows the values of water velocity to a certain extent, because the strong current washes away the animals. It was found that optimum water velocity for larvae is about 2 m/sec, and on reaches with smaller and greater values of water velocity the number of individuals decreases or different species can be found.

Higher number of individuals together with increasing water velocity has two main reasons: higher water velocity means larger amount of dissolved oxygen, and the stronger velocity washes more food to the larvae.

The close relationship between water velocity and number of individuals can be altered only by pollution. On the third of sampling place at Pilisszentlászló, in spite of high water velocity (2.4 m/sec) the number of individuals is small (20 larvae/m^2), while on the 11th sampling site with similar water velocity values (2.3 m/sec) the number of individuals is almost 13 times larger than at the previous one (250 larvae/m^2). It demontrates the effect of pollution on the abundance very well. To summarize the above mentioned facts, the pollution is obviously shown by low level of dissolved oxygen and low number of individuals of larvae.

Altogether 5.3% of all aquatic insect larvae and amphipods were among and under stones. Stones are the most frequent substrates in the creek. The relation between distribution of larvae and size of stones is discussed below.

In the case of sample sites with 1 m/sec flow-velocity, Fig. 5 demonstrates the number of individuals and size of stones belonging to them together. The distribution of larvae is influenced by stone size beside the primary effect of velocity. Most of the larvae can be found among or under 15-20 cm stones. The number of individuals on larger and smaller stones is considerably lower.

There is an additional ecological factor, water-depth, which has a great influence on the larva distribution. Although every maximum number of individuals is associated with 15-20 cm stone-size, there are some samples with lower abundance of larvae. The reason is the deeper creek-bed in these places.

The usual velocity, on 18 sampling places was 2 m/sec. It can be observed that the maximum abundance of larvae always belong to the stones with 15-20 cm diameter everywhere. Those numbers of individuals, which is associated with this stone-size, are going to be taken from the 18 samples. Eight samples remained out of the 50 ones, where velocity and stone-size are constant (2 m/sec and 15-20 cm), so the effect of water depth on distribution of larvae can be determined apart from the previous factors. The curves of abundance and water-depth in Fig. 7 are almost symmetrical to each other. Greater water-depth results in lower number of larvae and more shallow water in bigger number of larvae.

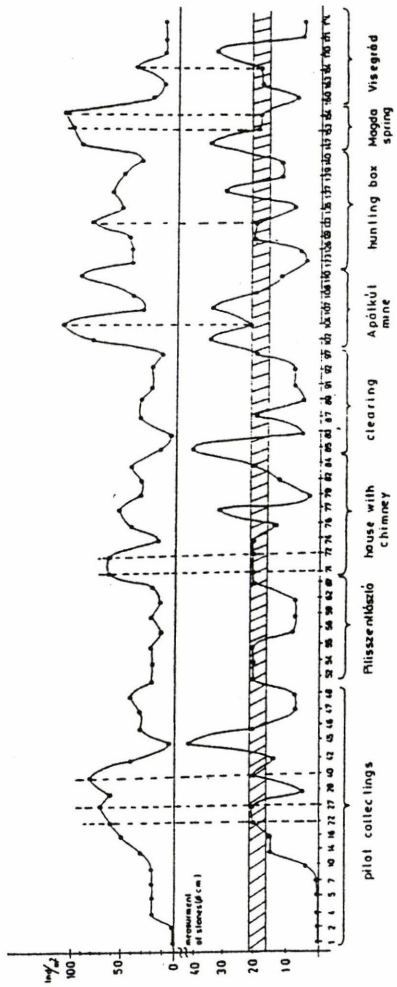

Fig. 5. Changing of stone size and number of individuals in case of permanent mean velocity (v= 1 m/sec)

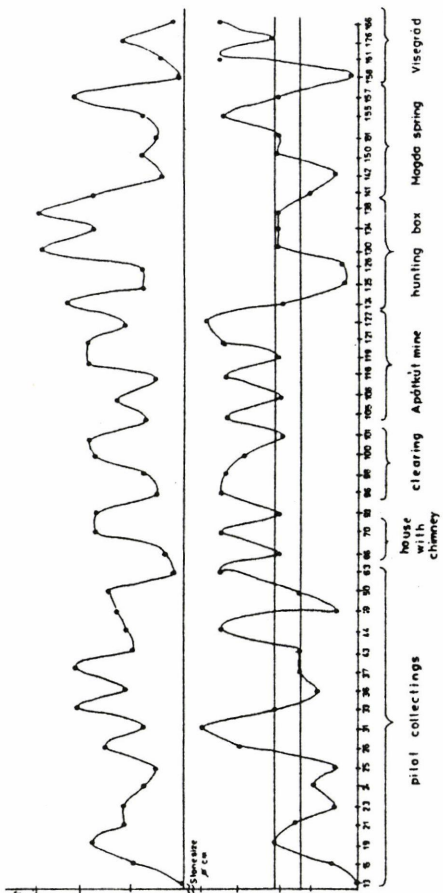

Fig. 6. Changing of stone size and number of individuals in case of permanent velocity

Finally, the relationships between species and aquatic insect-assemblages to substrate have to be examined. In the creek 4 kinds of substrates can be found: stones, detritus, creek-side vegetation reaching the water and sand. The rhitron organisms, with the exception of *Halesus* sp., are bound mainly to stones and they can be found in small numbers of individuals on sandy bottom (Fig. 8). It can be explained by the substrate-forming-effect of current. Silting up is possible only in the case of low water velocity, so the dissolved oxygen content is smaller, there are no hiding-places and food, that is why no aquatic larvae were found on this type of bottom.

Detritus can also be found in places with low water current, but in contrast to sand it has one advantage for larvae: this detritus is food. That is why larvae live here, although in low numbers (mainly *Baetis rhodani* and *Halesus* sp.).

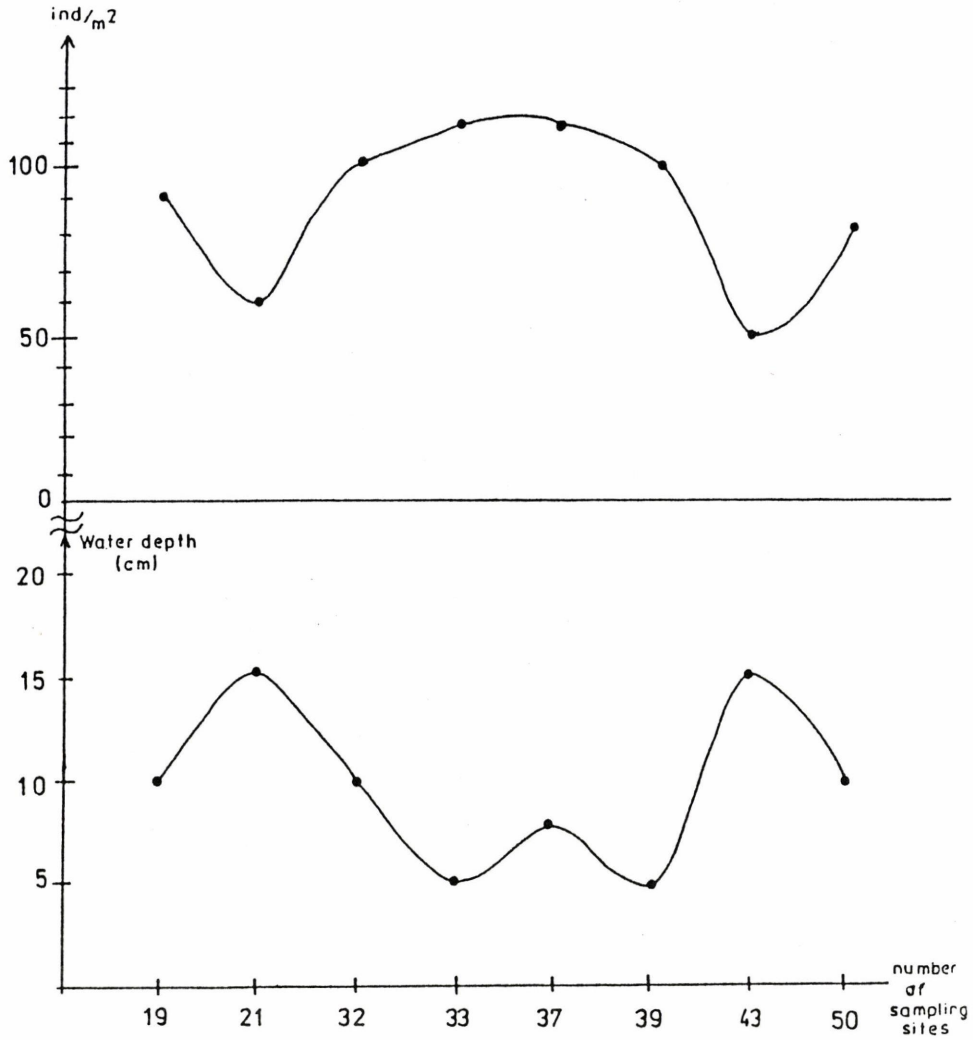

Fig. 7. Connection between abundance of larvae and waterdepth in the course of exploratory collection in case of permanent water velocity (2 m/sec) and stone size (15–20 cm)

Vegetation reaching the water from creek side does not mean low water velocity and small dissolved oxygen content at all. Here larvae can be found in greater number of individuals and species. 57% of Lymnephilidae live on this type of substrate.

Finally, on areas with highest water velocity and largest dissolved oxygen content, all of the 8 species can be found in great numbers.

The figures show the percentage of number of individuals of some collected species. *Epeorus silvicola* and *Hydropsyche pellucidula* we found only on stones. *Epeorus silvicola* requires stone and current in the largest extent among the other larvae. Morphologically, the body of the larva of this species is the most flattened, which adopted the most to the strong current.

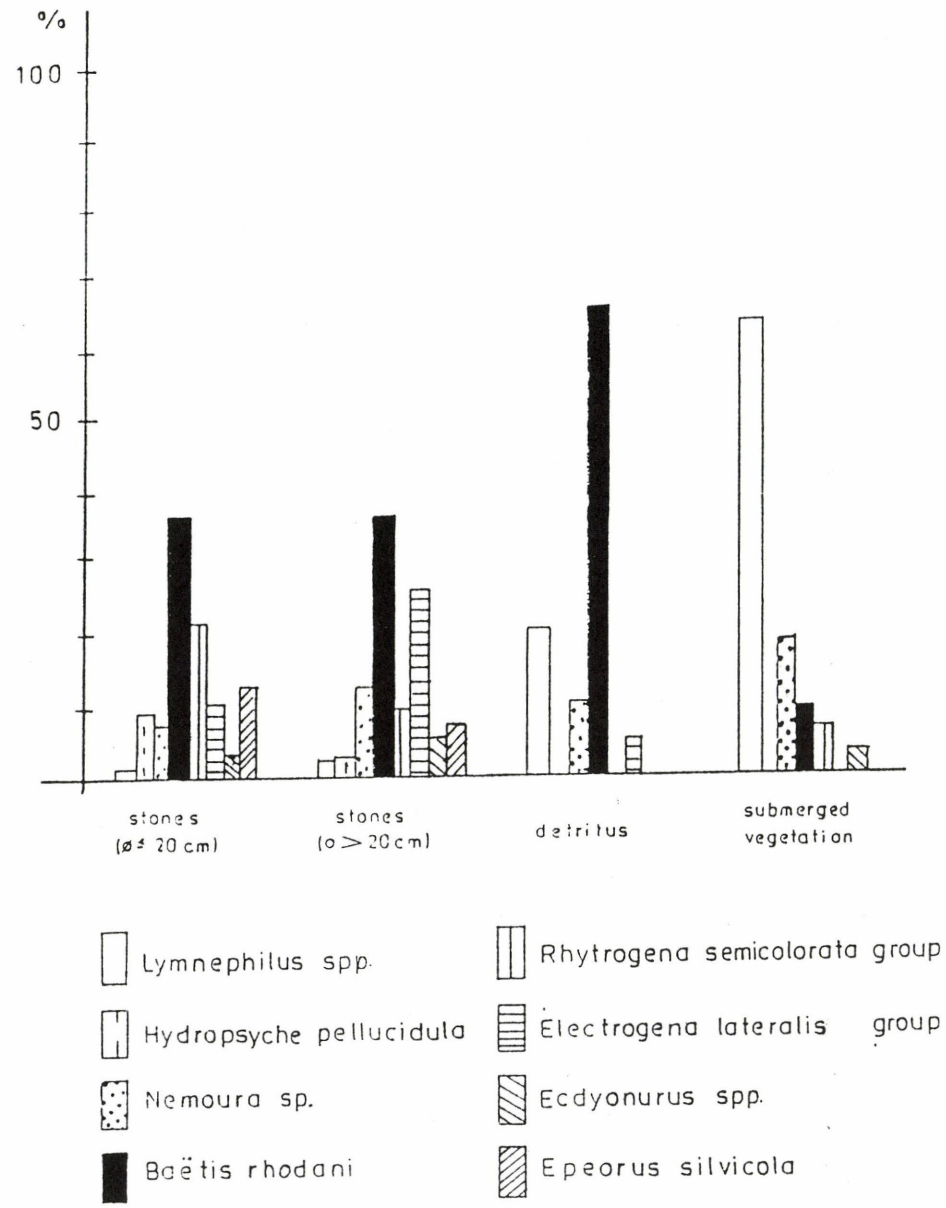

Fig. 8. Distribution of frequent larvae species in different types of substrates

Hydropsyche pellucidula spins its net among stones in strong water current. These two species are typical representatives of stony substrate.

All of the eight species can be found on small and big stones, in the largest percentage *Baetis rhodani* can be found on both places, it is the most common species along the creek. *Epeorus silvicola*, *Hydropsyche pellucidula*, *Rhithrogena semicolorata* can be found among small stones, *Ecdyonurus venosus* group and *Electrogena lateralis* are among larger stones in great number.

Table 4. Distribution of the more frequent taxa (%) on different substrates

Taxa	Substrate			
	Stone	Plants	Detritus	Sand
Epeorus silvicola	100	-	-	-
Ecdyonurus venosus group	96	4	-	-
Electrogena lateralis group	99	-	1	-
Rhithrogena semicolorata group	98	2	-	-
Baetis rhodani	97	1	2	-
Nemoura sp.	89	8	3	-
Hydropsyche pellucidula	100	-	-	-
Halesus sp.	31	57	12	-

The typical species are among large stones. *Electrogena lateralis* is found in the upper part of the creek, but among small stones *Rhithrogena semicolorata*, *Ecdyonurus venosus* group on the lower part of the creek among large stones. *Epeorus silvicola* and *Hydropsyche pellucidula* can be found among small stones in greater number.

Altogether 4 species live on detritus. Among them *Baetis rhodani* can be found in the greatest number, it does not require high level of dissolved oxygen and it changes its place from slow-flowing water to almost still-water. *Halesus* sp. and *Nemoura* sp. find their food in this substrate. The occurrence of *Electrogena lateralis* on detritus – even in small number – means that this species is able to live at low level of dissolved oxygen.

Plant fragments are food for *Halesus* sp. and *Nemoura* sp., the previous species makes its case from these material. These are the dominant taxa of the fauna living on wood branches, leaves and submerged vegetation.

All ecological factors, which have influence on the aquatic insect distribution (dissolved oxygen content, water discharge, water-depth, substrate, food type) are in very close connection with the mean velocity of water.

Summary

1376 insect larvae and amphipods (7 Ephemeroptera , 6 Plecoptera, 4 Trichoptera, 1 Coleoptera, 1 Megaloptera, 3 Diptera and 1 Amphipoda taxa) were collected in 174 samples. The number of species and individuals of invertebrates is great in the creek even in winter. The reason is the low water-temperature and high dissolved O_2 level, caused by high water velocity.

The current of water is rather strong, in winter the average water velocity is about 1 m/sec, much stronger than the values of the creeks in Mátra and Bükk Mts estimated by Oláh (1967) and Kiss (1978, 1979).

Distribution of larvae primarily depends on the mean velocity of water. The higher dissolved oxygen concentration allows the greater number of individuals of larvae. The number of

individuals decreases above 2 m/sec speed, because the larvae are more strongly washed away by water.

At the source of the creek, Pilisszentlászló, the level of dissolved oxygen and the number of larvae are low, because the creek is strongly polluted. At the next transects the cleaning of the creek is accompanied with higher oxygen-level and greater number of larvae, finally at the lowest place, Visegrád, the water is polluted again but in smaller extent than at Pilisszentlászló.

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